DOCUMENT RESUME

ED 105 997 PS 007 887

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TITLE Teacher Level of Questioning and Problem Solving in Young Children.
PUB DATE Mar 75
NOTE 20p.; Paper presented at the Annual Meeting of the American Educational Research Association (Washington, D.C., March 30 - April 3, 1975)

EDRS PRICE MF-$0.76 HC-$1.58 PLUS POSTAGE
DESCRIPTORS Abstraction Levels; Classroom Environment; *Cognitive Development; Interaction Process Analysis; Preschool Children; Preschool Education; *Problem Solving; *Questioning Techniques; Standardized Tests; Student Teacher Relationship; Task Analysis; *Teacher Role

ABSTRACT

Middle and upper class 3- and 4-year-old children were exposed to three consecutive 5-week treatment conditions in the naturalistic setting of a half-day laboratory nursery school program. During the first treatment condition, the teacher emphasized low level cognitive questions; during the second, high level cognitive questions; and during the third, low level cognitive questions. The level of teacher's cognitive demands for all treatment conditions was classified according to the observational instrument, the Individual Cognitive Demand Schedule (ICDS). Subjects significantly increased their scores on two verbal problem solving tasks following exposure to high level cognitive questioning and significantly decreased their scores on the same tasks following exposure to low level cognitive questioning. (Author/CS)

ED105997

Session number C-34

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TEACHER LEVEL OF QUESTIONING AND PROBLEM SOLVING IN YOUNG CHILDREN

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ABSTRACT

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Middle and upper class three- and four-year-old children were exposed to three consecutive five-week treatment conditions during the naturalistic setting in a half-day laboratory nursery school program. During the first treatment condition, the teacher emphasized low level cognitive questions; during the second, high level cognitive questions; and during the third, low level cognitive questions. Ss significantly increased their scores on two verbal problem solving tasks following exposure to high level cognitive questioning and significantly decreased their scores on the same tasks following exposure to low level cognitive questioning.

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TEACHER LEVEL OF QUESTIONING AND PROBLEM SOLVING IN YOUNG CHILDREN

Traditionally, instructional programs in American education have strongly emphasized the goal of transmitting subject matter content. However, it is becoming increasingly more difficult and less feasible to base curricula on the acquisition of facts. During the past decade early childhood educators have begun to recognize the importance of the development of intellectual operations other than those associated with factual knowledge.

Young children are faced with countless problems of various types and dimensions in their day-to-day interactions with both home and school environments. It appears that being exposed to a setting which emphasizes the transmission of factual knowledge is inadequate in helping the child to develop styles of thinking which enable him to seek effective solutions to problems.

As an area of study, problem solving has received its share of attention in the psychological literature. The single impression that emerges from the abundance of literature in the area is that there is little consensus on the definition of the problem solving process as a mode of thinking. Definitions vary in elaborateness and emphases. For example, Gagne (1964) describes problem solving as the most complex type of human learning, the pinnacle of the learning hierarchy. He differentiates problem solving from other forms of learning in that the learning situation never involves behavior which could by simple summation constitute the criterion performance, and what is learned must be generalizable to a class of problems.

A quite different assumption is made by Guilford and his associates who do not consider problem solving as a cognitive operation, but as a broad concept which cannot be located in the system of intellectual factors. Each instance

of problem solving is thought to draw upon its own particular combination of intellectual resources, depending on the nature of the problem and the strategy of the problem solver (Hoepfner, 1969).

Shaftel and Crabtree (1963) see problem solving as essentially a "search" for solutions to situations that have novel elements in them. They maintain that the process of search is as important as answers or products.

Freeman and Stern (1972) describe eight distinct abilities that underlie problem solving, two of which are fluency and flexibility. These same two abilities have been described by Guilford as aspects of divergent thinking. The former investigators consider problem solving as the highest level thinking skill which integrates those eight analytic abilities.

These and other definitions of problem solving, however, do seem to include at least three aspects: discovery, novelty, and generalizability.

Given that problem solving is an important process in the young child's overall development, teachers need to be concerned with the growth of problem solving facility of the young children under their direction. Only a few investigators have emphasized the teacher's questioning as a basic technique for guiding young children through the "search" or "inquiry" process (Blank, 1973; Estvan, 1969; Taba and Elzey, 1964; and Zimmerman and Bergen, 1971).

A number of studies have been conducted using elementary and high school students as subjects to measure the teacher's level of questioning and its effects on students' performance (Davis and Tinsley, 1967; Gallagher and Aschner, 1963; Hunkins, 1968; Hunter, 1969). The results of these studies indicate that teachers at all levels are asking an overwhelming percentage of questions which fall in the factual, recall categories, with questions requiring expression of higher cognitive processes being virtually absent from the classroom.

However, it seems that the few programs which have been designed for the specific purpose of improving teachers' questioning practices have been effective in meeting this goal (Borg, et al., 1970; Farley, 1968; Houston, 1938). In addition, there is some evidence to support the notion that when teachers have been trained to ask higher level questions, performance of students improves, at least immediately following exposure to such questions (Hunkins, 1968).

Unfortunately investigations in the area of teacher questioning and how it might relate to facilitating problem solving abilities with nursery school and kindergarten children is almost non-existent. In fact, teacher questioning at this level has been almost totally neglected in empirical research. The present study was designed to give some insight into the effects of a teacher's level of questions on certain problem solving tasks performed by the young children under her direction.

Method

Subjects

Subjects were thirteen children, six females and seven males, enrolled in one class in a laboratory nursery school, three hours a day, four days a week. The mean age of Ss was 49 months; mean IQ was 107; all Ss were classified as having either high or middle SES (Warner, 1960).

Pre- and Post-test Measures

Shaftel Photo Problems. This measure attempted to determine the child's ability to generate verbal alternative solutions to selected problem situations. Ss were shown individually three large photographs, each depicting a problem believed to be familiar to most young children. These photos are part of the Words and Action Program: Role Playing Photo-problems for Young Children (Shaftel and

Shaftel, 1967). E identified the problem depicted in the picture for the child and asked him to generate as many verbal solutions to the problem as he could. The child was asked after each response if there were any other solutions until he indicated he could think of none.

Similarities Test. This measure was developed by Smothergill, Olson, and Moore (1971) and consists of a series of small toys or other objects similar in several different ways. Each S was shown objects in pairs and was asked to generate as many verbal similarities as he could between the two. Again the S was asked after each response if there were any other possible similarities until he indicated there was none.

Testing was done by an experimenter unfamiliar with the nature of the study. Pre- and post-test sessions were tape-recorded for analyses of responses. The total number of alternative solutions generated for the problem situations and the total number of similarities generated between pairs of objects were computed from the tape recordings.

A reliability coefficient of the pre- and post-test instruments was obtained by a test-retest method on a random sample of fifteen children enrolled in other classes at the laboratory school. .94 was obtained for the Shaftel Photo Problems measure and .91 for the Similarities Test measure.

To assure equivalence of the different forms for the pre- and post-tests of the Similarities Test, both forms were administered at the same sitting to the above random sample of fifteen children with a correlation coefficient of .93 being obtained.

Classification System for Coding Teacher Questions

In this paper the term "cognitive demands" is used to refer to questions (and occasionally statements) by the teacher which appear to place demands on the cognitive

processes of the children to whom they are directed. The teacher's cognitive demands for all treatment conditions were classified according to the observational instrument, the Individual Cognitive Demand Schedule (ICDS) (Lynch and Ames, 1971). This instrument categorizes cognitive demands on a continuum with each type of demand being a unique combination of several features of cognition, with each level placing somewhat more complex demands on the child than the one preceding it. The instrument includes four low level categories, seven high level categories, and two non-cognitive categories not used in the study. Specifically, according to the ICDS, questions that can be classified as requiring the following responses from the child are considered low level questions: Habitual Responding, Observing-Discriminating, Stringing, and Remembering. Those questions which require the following responses from the child are classified as high level: Explaining, Defining-Classifying, Applying-Comparing, Inferring, Making Believe, Value Judging, and Problem Solving. Prior to the inception of the study, the investigator, using video tapes, established an inter-rater reliability coefficient with two other observers of .85.

Teacher Training

During the summer before the collection of the data the teacher participating in the study learned all eleven categories of the ICDS to be used in the study, using the training booklets provided by the developers of the instrument. Coding of video tapes constituted further training until the investigator was certain that the teacher could use and distinguish between low and high level categories. The data presented below confirm that she was sufficiently trained to use the appropriate categories for each treatment condition. Participating students who each spent three hours a week in the laboratory were trained in a similar manner.

Coding of Cognitive Demands During Treatment Conditions

The teacher's cognitive demands were coded during the naturalistic setting of the entire daily session of each day of each treatment condition, for a total of 60 days. Each time the teacher asked a question (or made a statement) which could be classified as a cognitive demand, the observer recorded on a data sheet the category of the demand and the child to whom it was directed. Because of the open framework environment an observer was able to code only one adult at a time. Consequently, due to the number of participating students and the absence of available observers, only the teacher herself was coded. Student participators were observed from time to time to determine if they were asking questions appropriate to the designated level for the treatment condition. Two observers shared the coding with an inter-rater reliability esbablished at .88.

Treatment Conditions

The design for the present investigation was a Treatments-by-Subjects, or Repeated Measures, Design, which analyzed the effects of successive experimental manipulations on one group of Ss (Bruning and Kintz, 1968). Ss were tested after each of three treatment conditions, rendering for each S a pretest score and three post-test scores. Each treatment condition lasted five weeks, or a total of 20 days.

During the first treatment condition, the teacher restricted her cognitive demands, insofar as possible, to the four low level categories of the ICDS. Immediately following post-testing, the second treatment condition began, during which the teacher eliminated her use of low level demands, insofar as possible, and made use of all seven categories of high level demands of the ICDS. During the third and final treatment condition the teacher again reverted to the use of low level demands, restricting high level demands as much as possible. This treatment condi-

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tion was included in the design to strengthen the possibility that if changes in Ss' performance occurred in the expected direction at the end of each treatment condition, then these changes would more likely be the result of differential treatment conditions rather than the result of maturation, nursery school experience, etc.

During all treatment conditions children were participating in their normal nursery school activities. No attempt was made to alter the environment in any way except in the level of questions asked by the teacher. The teaching situation remained natural. No specific tasks were assigned. The teacher merely used the designated levels of cognitive demands in every appropriate situation throughout each day of the treatment.

Results

During the first treatment condition the teacher made a mean number of 66 low level cognitive demands and 2.95 high level demands per day. Computed on a percentage basis, low level cognitive demands comprised from 87 to 100% of the teacher's daily demands, with high level demands occurring from 0 to 13% of the time.

During the second five-week treatment condition, the teacher made a mean number of 26.55 low level cognitive demands and 101.4 high level cognitive demands per day. On a percentage basis, low level cognitive demands were made on Ss from 14 to 30% of the time, with the exception of day 15, when the teacher's low level demands comprised 36% of the total. High level cognitive demands during the second treatment condition comprised 70 to 86% of total questions, with the exception of day 15, when the percentage only reached 64%.

During the third and final five-week treatment condition, the teacher made a mean number of 59.6 low level cognitive demands and 3.35 high level cognitive demands per day. Low level demands ranged from 82 to 100% of total daily cognitive demands, with high level demands ranging from 0 to 18%.

These data indicate without statistical treatment that there were substantial differences in the number of high level and low level cognitive demands made of the Ss in each of the three treatment conditions, with the first treatment condition emphasizing low level cognitive demands; the second, high level demands; and the third, a return emphasis to low level demands.

Pre- and Post-test Scores on the Shaftel Photo Problems

Mean scores and standard deviations obtained on the Shaftel Photo Problems for the four testing periods are reported in Table 1.

Insert Table 1 about here

An analysis of variance for a repeated measures design (Bruning and Kintz, 1968) was performed for this measure on the four sets of data (Table 2).

Insert Table 2 about here

It can be seen from Table 2 that the obtained F value of 12.75 was significant beyond the .001 level of confidence. To determine where the differences lay, a t test for correlated data (Bruning and Kintz, 1968) was used to test the difference between the mean scores of: the pretest and the first post-test, the first and second post-tests, and the second and third post-tests.

Insert Table 3 about here

Table 3 indicates that a t of 1.41 was obtained between the mean scores on the pretest and the first post-test, after Ss were exposed to a treatment condition

emphasizing low level cognitive demands, with this difference being statistically non-significant. In fact, Ss slightly increased their mean score on this measure from 7.15 to 8.38 (Table 1).

A t of 8.78 ($p < .001$) was obtained for the difference between the means of the second and third post-tests (Table 3). Ss' mean scores increased from 8.38 to 15.85 (Table 1) after being exposed to a treatment condition emphasizing high level cognitive demands.

Finally, a t of 3.79 ($p < .01$) was obtained for the difference between the mean scores of the second and third post-tests, after Ss were again exposed to a treatment condition emphasizing low level cognitive demands (Table 3). It may be noted (Table 1) that Ss' mean scores decreased from 15.85 to 10.08 after the third treatment condition.

These data indicate that there was no significant difference between the mean number of alternative solutions that Ss generated to the Shaftel Photo Problems after an initial exposure to a treatment condition emphasizing low level cognitive demands. In addition, Ss generated a significantly greater number of alternative solutions to the problems measure after being exposed to a treatment condition in which the teacher emphasized high level cognitive demands. Finally, Ss generated significantly fewer alternative solutions to the Shaftel Photo Problems after being exposed to a treatment condition in which the teacher again emphasized low level cognitive demands.

Pre- and Post-test Scores on the Similarities Test Measure

Mean scores and standard deviations were calculated for the Similarities Test measure for each of the four testing periods (Table 4).

Insert Table 4 about here

Following the same procedure described above, an analysis of variance for a repeated measures design (Bruning and Kintz, 1968) was performed for this measure on the four sets of data (Table 5).

Insert Table 5 about here

As reported in Table 5, the obtained F value of 26.15 for this measure was significant beyond the .001 level of confidence. Again, to determine where the differences lay, a t test for correlated data (Bruning and Kintz, 1968) was used to test the difference between the mean scores of: the pretest and the first post-test; the first and second post-tests, and the second and third post-tests.

Insert Table 6 about here

Table 6 indicates that a t of .126 was obtained between the mean scores on the pretest and the first post-test. Even though Ss slightly increased their mean score, from 8.15 to 8.30 (Table 4), after being exposed to a treatment condition emphasizing low level cognitive demands, this difference was statistically non-significant.

A t of 8.27 ($p < .001$) was obtained for the difference between the mean scores of the second and third post-tests (Table 6). Ss' mean scores increased from 8.30 to 18.31 on this measure (Table 4) after being exposed to a treatment condition emphasizing high level cognitive demands.

Finally, a t of 7.25 ($p < .001$) was obtained for the difference between the mean scores of the second and third post-tests (Table 6), after Ss had been exposed to the third treatment condition, which again emphasized low level cognitive demands. It may be noted (Table 4) that Ss' mean scores decreased from 18.31 to 9.46 after the final treatment condition.

Therefore, it is clear that there was no significant difference between the mean number of similarities Ss generated between familiar objects after being exposed to an initial treatment condition emphasizing low level cognitive demands. In line with their responses to the Shaftel Photo Problems, Ss generated a greater number of similarities between objects after being exposed to a treatment condition in which the teacher emphasized high level cognitive demands. Similarly, Ss generated significantly fewer similarities between objects after being exposed to a final treatment condition in which the teacher emphasized low level cognitive demands.

Discussion

The data presented above strongly suggest the importance of the role of teachers in promoting the growth of problem solving facility in the young children under their direction. More specifically, the data seem to support the thesis that exposure to the teacher's high level cognitive questioning results in children's ability to generate significantly more alternative solutions to problems, as well as significantly more similarities between familiar objects in their environment, two abilities seen by the investigator as being among several abilities involved in the total process of problem solving. However, the data should be viewed as suggestive rather than indicative, due to the size and homogeneity of the sample.

The data indicate that the children in the study did not significantly change their performance on the two problem solving measures after the first treatment condition. This is hardly surprising in view of the possibility that whatever "naturally occurring" cognitive maturation which normally would be evident might have been offset by the lack of any attention on the part of the teacher to high level cognitive questioning. Or it is possible that even low level questioning may have had some slight positive effect on these abilities, by helping children to approach problems in a more questioning manner.

The extremely significant increase in scores on both measures after the second treatment condition (from 8.38 to 15.85 on the Shaftel Photo Problems and from 8.30 to 18.31 on the Similarities Test) was somewhat surprising to the investigator, who had not anticipated significant differences greater than at the .01 level of confidence, at best. On examining the data on the teacher's number of total questions in each of the three treatment conditons, one possible explanation occurs. It should be recalled that during the first treatment condition emphasizing low level cognitive demands, the teacher made a mean number of 66 low level demands per day, or a total of 1,320 for the five-week period, while she made only 2.95 high level demands per day, for a total of 59.

On the other hand, when the teacher shifted to the second treatment condition, which emphasized high level cognitive demands, she made a mean number of 101.4 of this type per day, or a total of 2,028 high level cognitive demands for the entire period. Her mean of 26.55 low level demands per day resulted in a total of 531 for the entire period.

Looking at these figures, it is easy to see that the teacher asked almost twice as many total questions during the second treatment condition as during the first. Further, the fact that she emphasized the appropriate level of questions to a far greater extent during the second condition than during the first suggests the possibility that this particular teacher may have found it easier to ask high level than low level questions, or that she was influenced by her knowledge of the general nature of the study. These factors, either alone or in combination, might offer some insight into the highly significant increase in scores following Ss' exposure to high level cognitive demands.

The third and final treatment condition emphasized low level questions. In terms of total number of questions asked by the teacher, the third treatment condi-

tion was little different from the first, with a mean number of 59.6 low level demands or a total of 1,192, and mean number of 3.35 high level cognitive demands per day for a total of 67. It should be noted that Ss did, in fact, significantly decrease their scores on both measures after the third treatment condition, but scores did not fall as low as they had been prior to any exposure to high level questioning. These data suggest that either there may have been some slight residual effects of previous high level questioning, or that scores would naturally increase somewhat from the pretest as a result of maturation and/or experience not related to questioning, or as a result of experience in testing. Since the differences between the first post-tests and the third post-tests were rather small, one of the latter explanations seems more likely.

In general, the results of the present study are consistent with results of other studies conducted with older children concerning the effects of teachers' questions on pupil performance. Unfortunately, studies of this nature are scarce, especially with teachers of nursery and kindergarten children. However, a few investigators have ascertained that an elaborated code on the part of the adult working with a young child produced cognitive styles more conducive to problem solving and reflection, with the use of questioning to help the child search for solutions to problems being a vital aspect of an elaborated code (Bee, et al., 1969; Hess and Shipman, 1965; Smothergill, Olson, and Moore, 1971).

The present study differed from those above in two major ways: first, only the level of questioning was manipulated, with other aspects of adult verbalization such as support and elaborative statements being excluded; second, children were exposed to the treatment condition daily for the duration of the naturalistic setting rather than for short periods of specialized teaching sessions apart from the naturalistic setting.

One of the most encouraging implications of the present investigation is that apparently a teacher can be trained to effectively ask high level questions in the naturalistic setting with young children. It seems that the use of an instrument such as the Individual Cognitive Demand Schedule can be an effective teacher training tool to help teachers become aware of the kinds of questions they are asking in the classroom and to help them change their question-asking techniques so that they can better foster desirable thinking skills in the young children whom they teach.

Summary

In summary, the present investigation suggests that exposure to high level cognitive questions in the naturalistic setting is instrumental in producing at least temporary gains in scores on certain problem solving measures in young children. Specifically, the study lends credence to the hypothesis that young children generate a significantly greater number of alternative solutions to problems presented and a significantly greater number of similarities between familiar objects after being exposed to high level cognitive questioning in their daily nursery school activities than they do after being exposed to low level cognitive questioning.

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TABLE 1

MEANS AND STANDARD DEVIATIONS OF THE SHAFTEL PHOTO PROBLEMS FOR FOUR TESTING PERIODS

Testing Period	$\bar{x}$	S. D.
Pretest	7.15	2.8
Post-test I	8.38	3.43
Post-test II	15.85	3.65
Post-test III	10.08	4.88

TABLE 2

ANALYSIS OF VARIANCE FOR REPEATED MEASURES OF THE SHAFTEL PHOTO PROBLEMS

Source	SS	df	ms	F	p
Total	1506.16	51	---	---	---
Subjects	405.58	12	---	---	---
Treatments	567.08	3	189.02	12.75	<.001
Error	533.5	36	14.82	---	---

TABLE 3

$\underline{t}$ TESTS FOR DIFFERENCE BETWEEN MEANS OF PRE- AND POST-TESTS OF THE SHAFTEL PHOTO PROBLEMS

Means Tested	$\underline{t}$	p
Pretest & Post-test I	1.41	N. S.
Post-test I & Post-test II	8.78	<.001
Post-test II & Post-test III	3.79	<.01

TABLE 4

MEANS AND STANDARD DEVIATIONS OF THE SIMILARITIES TEST FOR FOUR TESTING PERIODS

Testing Period	$\bar{x}$	S. D.
Pretest	8.15	5.04
Post-test I	8.30	5.8
Post-test II	18.31	5.48
Post-test III	9.46	6.89

TABLE 5

ANALYSIS OF VARIANCE FOR REPEATED MEASURES OF THE SIMILARITIES TEST

Source	SS	df	ms	F	p
Total	2660.99	51	---	---	---
Subjects	1366.24	12	---	---	---
Treatments	895.60	3	298.80	26.15	<.001
Error	399.15	36	11.08	---	---

TABLE 6

$\underline{t}$ TESTS FOR DIFFERENCE BETWEEN MEANS OF PRE- AND POST-TESTS OF THE SIMILARITIES TEST

Means Tested	$\underline{t}$	p
Pretest & Post-test I	.126	N. S.
Post-test I & Post-test II	8.27	<.001
Post-test II & Post-test III	7.25	<.001

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